Introduction to Database Systems CSE 444

Lecture 24: Databases as a Service

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References

- Amazon SimpleDB Website
  - Part of the Amazon Web services
- Google App Engine Datastore Website
  - Part of the Google App Engine
- Microsoft SQL Azure Website
  - Part of the Azure platform

Motivation

- Running a DBMS is challenging
  - Need to hire a skilled database administrator (DBA)
  - Need to provision machines (hardware, software, configuration)
    - If business picks up, may need to scale quickly
    - In general, workload varies over time
- Solution: Use a DBMS service
  - All machines are hosted in service provider's data centers
  - Data resides in those data centers
  - Pay-per-use policy
  - Elastic scalability
  - Zero administration

Basic Features

- Data storage and query capabilities
- High availability guarantees
- Operations and admin tasks handled by provider

- **Elastic scalability**: Clients pay exactly for the resources they consume; consumption can grow/ shrink dynamically
  - No capital expenditures
  - Fast provisioning

Outline

- Database in the Cloud
  - DIY Database in the Cloud
  - RDBMS as a Service
  - Database as a Service
- Discussion
  - Technical challenges behind databases as a service
  - Broader impacts of databases as a service

Outline: Database in the Cloud

- **DIY Database in the Cloud**
  - **Amazon EC2 + Database software**

- RDBMS as a service
- Database as a service

DIY Database in the Cloud

- Setting up a database server
  - Buy land (building, room, server rack)
  - Buy computers and network gears
  - Install the hardware
  - Install OS
  - Install database server

- How can we do this using the cloud?

Amazon Web Services

- Since 2006
- “Infrastructure web services platform in the cloud”

- Amazon Elastic Compute Cloud (Amazon EC2™)
- Amazon Simple Storage Service (Amazon S3™)
- Amazon SimpleDB™
- Amazon CloudFront™
- Amazon Simple Queue Service (Amazon SQS™)

Amazon EC2

- Amazon Elastic Compute Cloud (Amazon EC2™)

- Rent compute power on demand ("server instances")
  - Select required power: small, large, or extra large instance
  - Share resources with other users
  - Variety of operating systems

- Includes: Amazon Elastic Block Store
  - Off-instance storage that persists independent from life of instance
  - Highly available and highly reliable

Amazon S3

- Amazon Simple Storage Service (Amazon S3™)
  - "Storage for the Internet"
  - "Web services interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web."
- Some key features
  - Write, read, and delete uniquely identified objects containing from 1 byte to 5 gigabytes of data each
  - Objects are stored in buckets, located in US or Europe
  - A bucket can be accessed from anywhere
  - Authentication
  - Reliability

Let's hook up what we've got!

- Buy an EC2 instance
- Buy database software
  - Pre-licensed Amazon Machine Image
- Launch your EC2 instance
- Hooray! ☺
  - Took less than 5 minutes to here!

Summary: DIY Database in the Cloud

- Pros
  - Fast provision of resource!
  - Full-control over software
    - Choose your favorite database software!
- Cons
  - Full-control over software
    - Operating system, backup, fault-tolerance, security, performance tuning, scaling, …
- Can cloud provider manage such detail?

Outline: Database in the Cloud

- DIY Database in the Cloud
- **RDBMS as a service**
  - **Amazon Relational Database Service**
  - **Microsoft SQL Azure**
- Database as a service

RDBMS as a Service

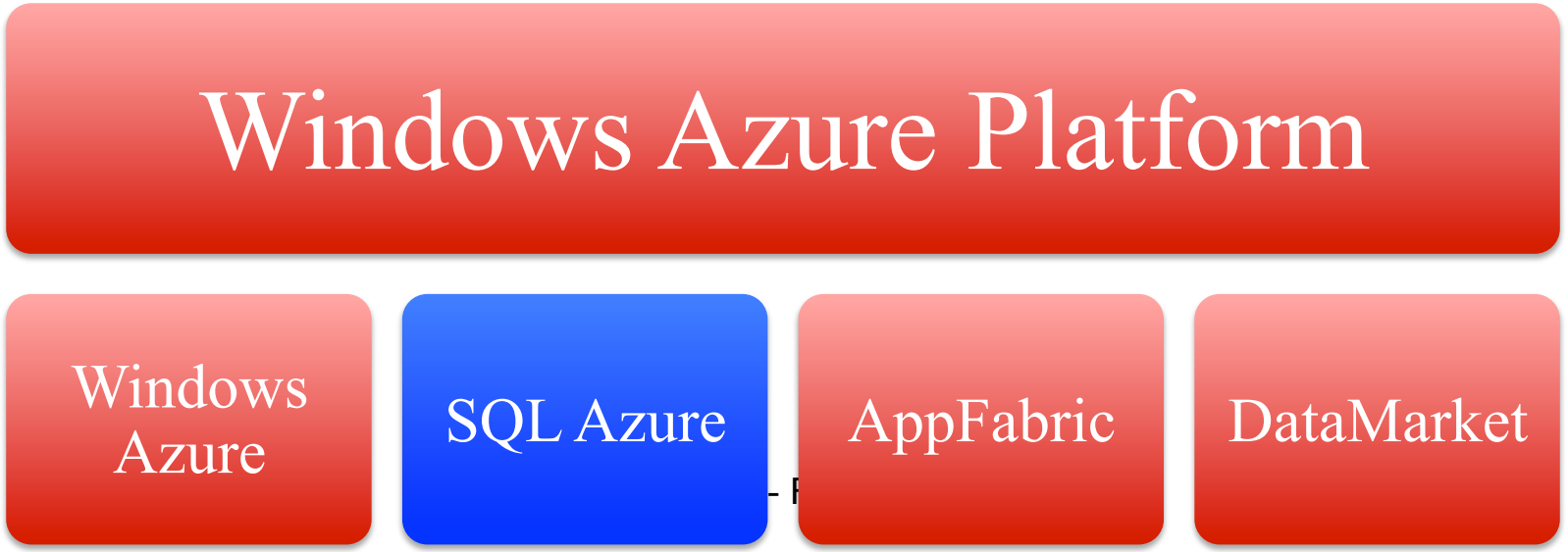
- Cloud provider manages
  - Operating system, Backup, Fault-tolerance, Scaling
- User manages
  - Schema, Data, Indexes, …
- Use your favorite SQL ☺
- Two services
  - Amazon Relational Database Service
  - Microsoft SQL Azure

Amazon Relational Database Service

- Features
  - Backed by MySQL
  - Easy administration
    - Backup, replication, adding more resources (CPU, disk)
    - Automated or initiated by AWS API or via management console
  - Database size: 5GB ~ 1TB per instance
- How to scale?
  - Adding more resources to master
  - Adding more *read-only* replicas

Microsoft Windows Azure Platform

- “Internet-scale cloud computing and services platform”
- “Provides an operating system and a set of developer services that can be used individually or together”



SQL Azure

- Virtualized SQL Azure Server cluster
  - Azure manages physical cluster
- SQL Azure Server
  - A logical SQL Server
  - Automatically replicated
  - Hosts up to 149 databases
  - 5 GB or 50 GB per database
- How to scale?
  - Partition across multiple databases
    - Automatically distributed across multiple machines

Summary: RDBMS as a Service

- Remove burden of database administration
  - Amazon RDS: automate common administration tasks
  - SQL Azure: separate logical/physical database cluster
- Pros
  - No change to existing applications
  - Support full SQL, transaction, consistencies
  - Highly-available, scalable
- Cons
  - Managing schema, indexes, partitioning, tuning, …

Outline: Database in the Cloud

- DIY Database in the Cloud
- RDBMS as a service

- **Database as a service**
  - **Amazon SimpleDB, Google App Engine**
  - Google Fusion Table, Big Query

Database as a Service

- RDBMS as a Service is good
  - But user still has to know a lot about database!
- Can cloud manage following?
  - Schema, Partitioning, Indexing

- Two services
  - Amazon SimpleDB
  - Google App Engine

Amazon SimpleDB

- "Web service providing the core database functions of data indexing and querying"

- **Partitioning**
  - Data partitioned into domains: queries run within domain

- **Schema**
  - No fixed schema
  - Objects are defined with attribute-value pairs

Amazon SimpleDB (2/3)

- **Indexing**
  - Automatically indexes all attributes
- **Support for writing**
  - PUT and DELETE items in a domain
- **Support for querying**
  - GET by key
  - Selection + sort
  - A simple form of aggregation: count
  - Query execution time is limited to 5 second (but can continue)

```
select output_list
from domain_name
[where expression]
[sort_instructions]
[limit limit]
```

Amazon SimpleDB (3/3)

- **Availability and consistency**
  - "Fully indexed data is stored redundantly across multiple servers and data centers"
  - "Takes time for the update to propagate to all storage locations. The data will eventually be consistent, but an immediate read might not show the change"
  - Consistent read, Conditional Put/Delete
- **Integration with other services**
  - "Developers can run their applications in Amazon EC2 and store their data objects in Amazon S3."
  - "Amazon SimpleDB can then be used to query the object metadata from within the application in Amazon EC2 and return pointers to the objects stored in Amazon S3."

Google App Engine

- "Run your web applications on Google's infrastructure"
- Key features
  - Dynamic web serving, with full support for common web technologies: apps serve web requests
  - Persistent storage with queries, sorting and transactions
  - Automatic scaling and load balancing
  - APIs for authenticating users and sending email
  - A fully featured local development environment that simulates Google App Engine on your computer
- Limitation: apps must be written in Python or Java

Google App Engine Datastore (1/3)

- "Distributed data storage service that features a query engine and transactions"
- **Partitioning**
  - Data partitioned into "entity groups"
  - Entities of the same group are stored together for efficient execution of transactions
- **Schema**
  - Each entity has a key and properties that can be either
    - Named values of one of several supported data types (includes list)
    - References to other entities
  - Flexible schema: different entities can have different properties

Google App Engine Datastore (2/3)

- **Indexing**
  - Applications define indexes: must have one index per query type
- **Support for writing**
  - PUT and DELETE entities
- **Support for querying**
  - Fetch an entity using its key
  - Execute a query: selection + sort
  - Language bindings: either invoke methods or write GQL
  - Lazy query evaluation: query executes when user accesses results

Google App Engine Datastore (3/3)

- **Availability and consistency**
  - Every datastore write operation (put/delete) is atomic
  - Support transactions
    - All operations must operate on entities in the same entity group
    - Cannot perform queries; can only get entities by their keys
  - Optimistic concurrency control

Summary: Database as a Service

- **Partitioning**: in all systems data is partitioned
- **Schema**: flexible schema
  - Different entities can have different attributes
- **Indexing**: all systems answer queries using indexes
- **Write** operations: put and delete
  - Some systems support transactions on objects within a group
- **Query** interface: primarily selection + sort
- **Availability and consistency**
  - All systems strive to achieve high availability
  - Some systems have strong consistency others weak

Comparison

	Hardware Admin.	System Admin.	Database Admin.	Scale	Feature
Traditional	High	High	High	Hard	High
DIY in the Cloud	None	High	High	Moderate	High
RDBMS as a Service	None	~ Low	Medium	~ Easy	High
Database as a Service	None	None	~ Low	Easy	~ High?

Related Database as a Service

- Google Fusion Table
  - http://www.google.com/fusiontables
  - Share your data with rest of the world!
  - Easy visualization, SQL-like query language
- Google Big Query
  - http://code.google.com/apis/bigquery/
  - Run SQL-like query over TB or PB of data in seconds!
  - Currently in preview

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Challenges of DBMS as a Service

- Scalability requirements
  - Large data volumes and large numbers of clients
  - Variable and heavy workloads
- High performance requirements: interactive web services
- Consistency and high availability guarantees
- Service Level Agreements
- Security
- Billing
- Loading/Exporting Data

Broader Impacts

- Cost-effective solution for building web services
- Content providers focus only on their application logic
  - Service providers take care of administration
  - Service providers take care of operations
- Security/privacy concerns: all data stored in data centers